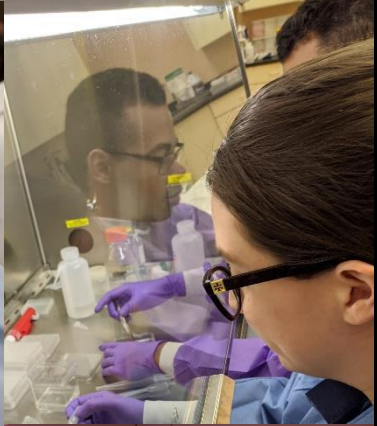
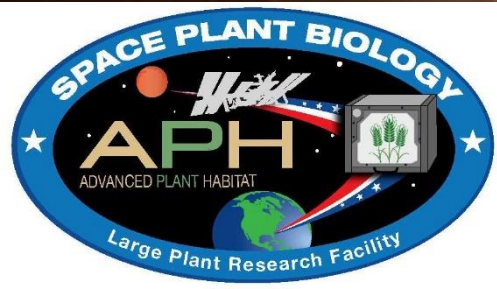


Greening the Black: Plants in Space

Gioia Massa

NASA, Kennedy Space Center, FL,
USA

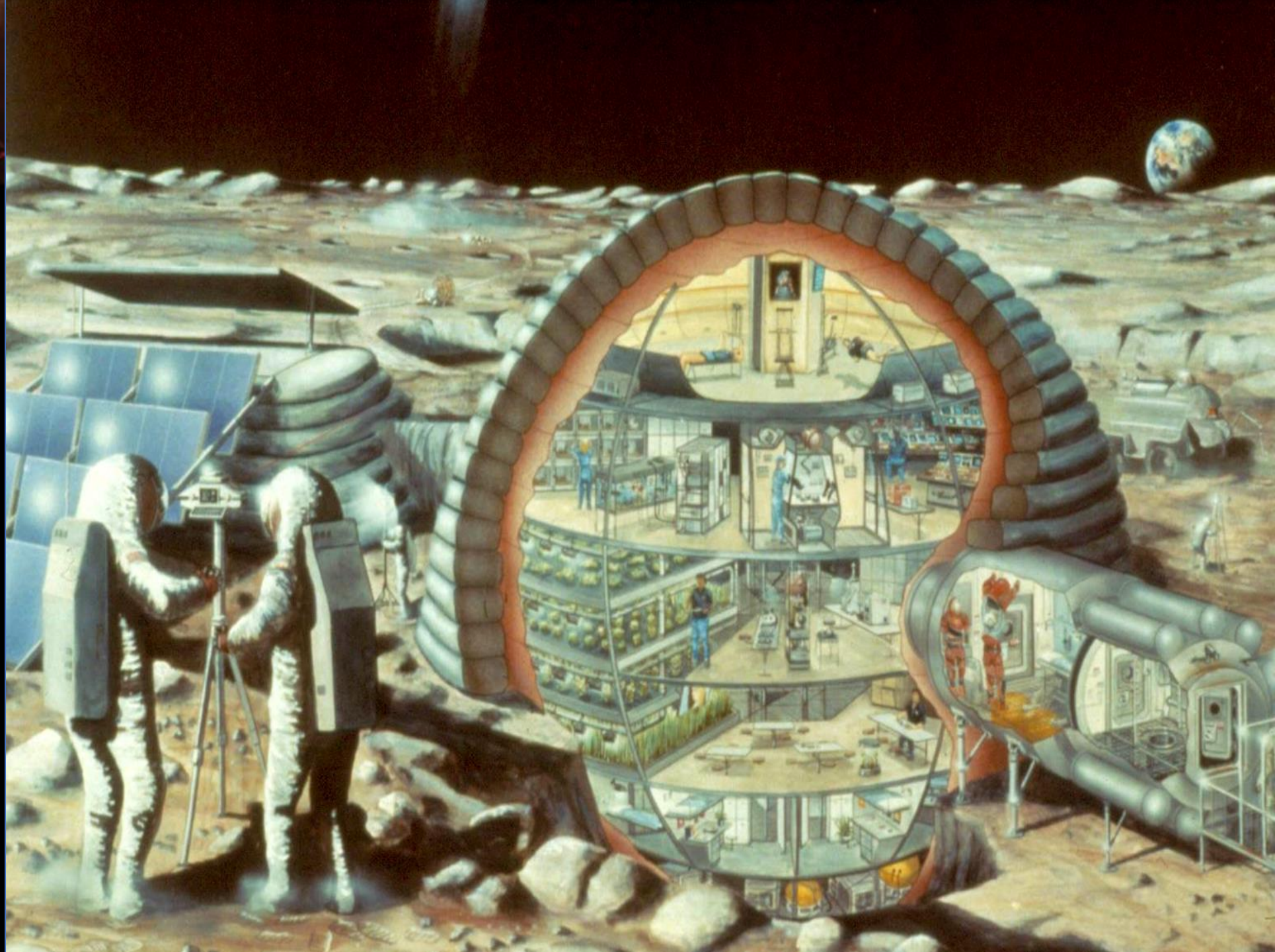




Why grow plants in space?

- Food
- Psychological well being
- Atmosphere
- Water









The Space Crop Production Vision

***Ensure Food System Security on Long Duration Missions
Beyond LEO***

Near-Term Goal

Nutrient Supplementation of Prepackaged Food

Long-Term Goal

Caloric Replacement to Facilitate Earth Independence

Space Crop Production Candidates

Salad
Leafy Greens
Tomato
Pepper
Radish
Strawberry
Green Onion
Pea
Carrot

Lettuce, Chinese cabbage, Swiss chard, Mizuna, Spinach



Staple Crops
White Potato
Sweet Potato

Rice
Wheat
Dried Bean
Soybean
Peanut

MINIMAL
PREPARATION /
COOKING

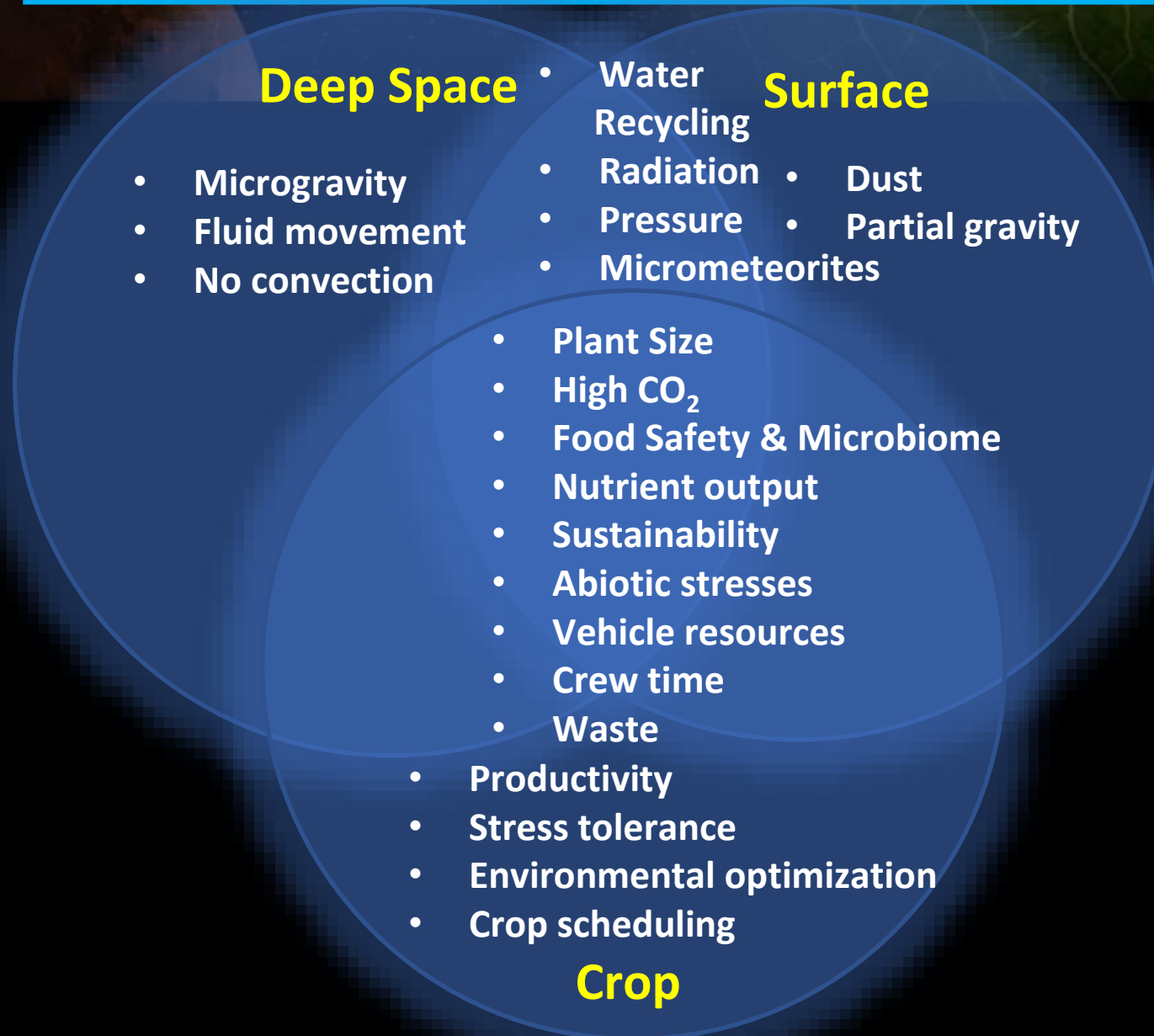
SIGNIFICANT
PREPARATION /
COOKING

CONSUMED
FRESH WITHOUT
PROCESSING

Herbs
Basil
Mint
Chives
Dill



Space Crop Production Challenges



Space Crop Production Roadmap For Exploration

ISS (Plant Research and H/W Technology)



Identify challenges and solutions for growing pick and eat crops in μg to support crew nutrition

Scale: Single Locker to EXPRESS Rack (8 Lockers)

GATEWAY (Plant Research)



Proving Ground to study the effect of deep space radiation on pick and eat crops in μg

Scale: Single Locker

MARS TRANSIT (Crop Production)



Operational μg Food Production capability for pick and eat crops to supplement crew diet

Scale: One to Two EXPRESS Racks (8-16 Lockers)

Ground (Plant Research and H/W Technology)



Develop space crop production concepts and strategies in support of destinations along the exploration roadmap

Scale: Single Locker to Module

LUNAR SURFACE (Research/Production)



Develop and deploy operational partial gravity systems for both nutritional support and caloric replacement as both a source of food for long duration lunar missions and as a demonstration for Mars

Scale: Single Locker to Module on 1 Base - Regenerative

MARTIAN SURFACE (Production)

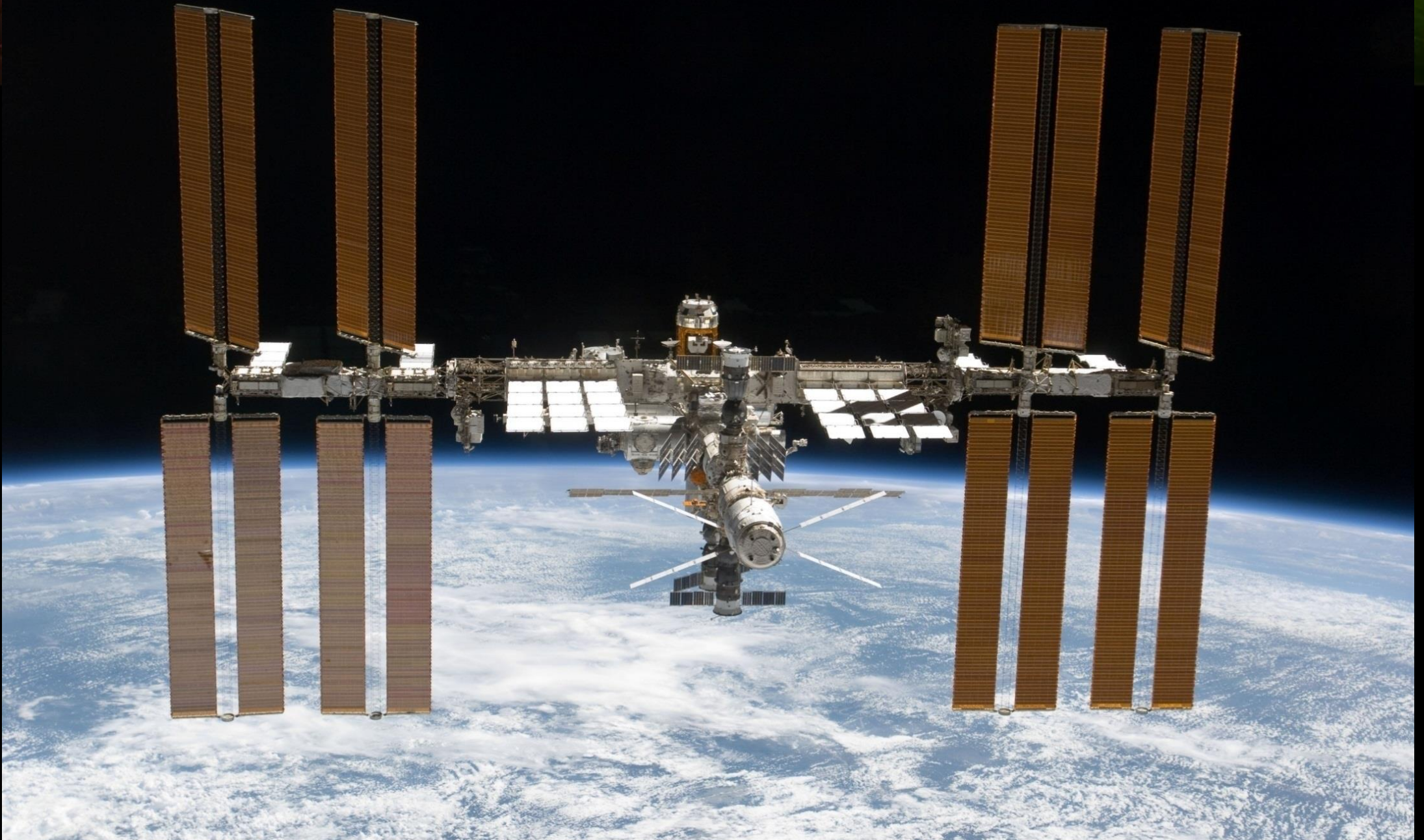


Leverage Lunar Surface experience in Food Production systems to extend Earth Independence for Mars missions

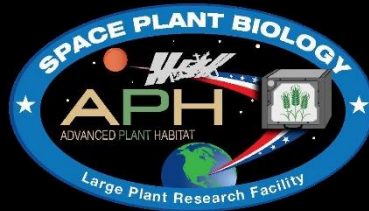
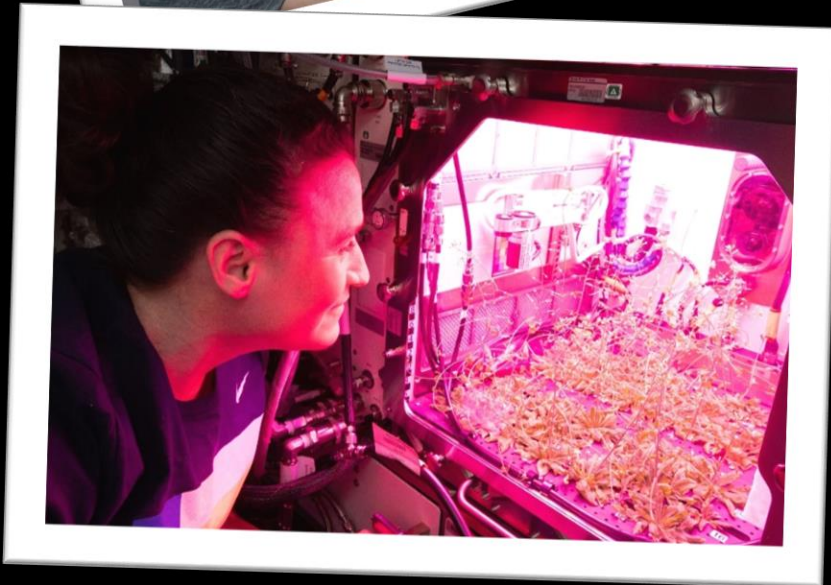
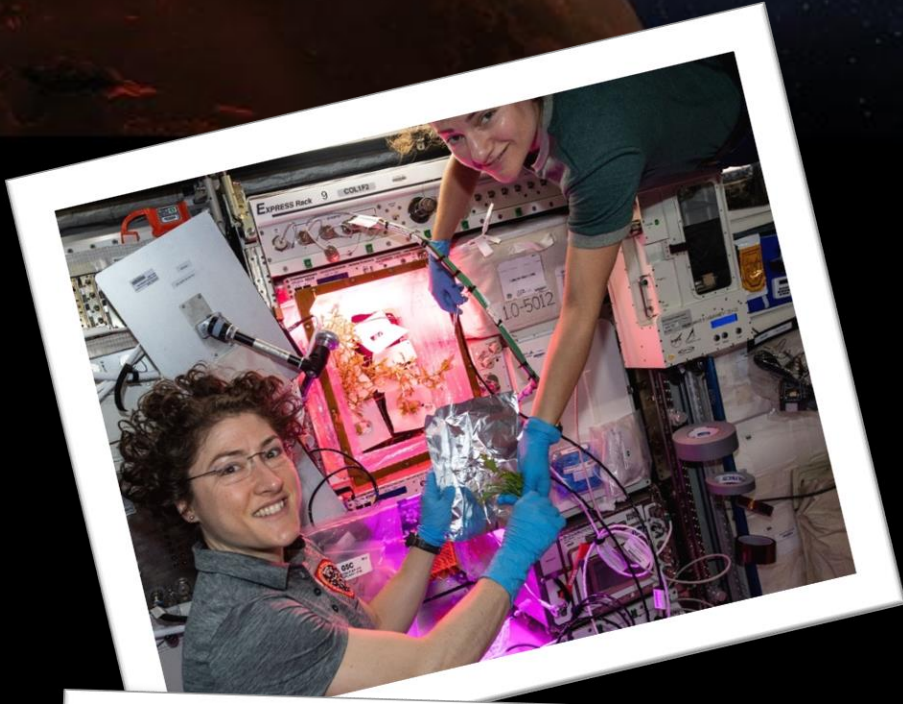
Scale: Single Locker to Module on 1 Base - Regenerative EDLSS



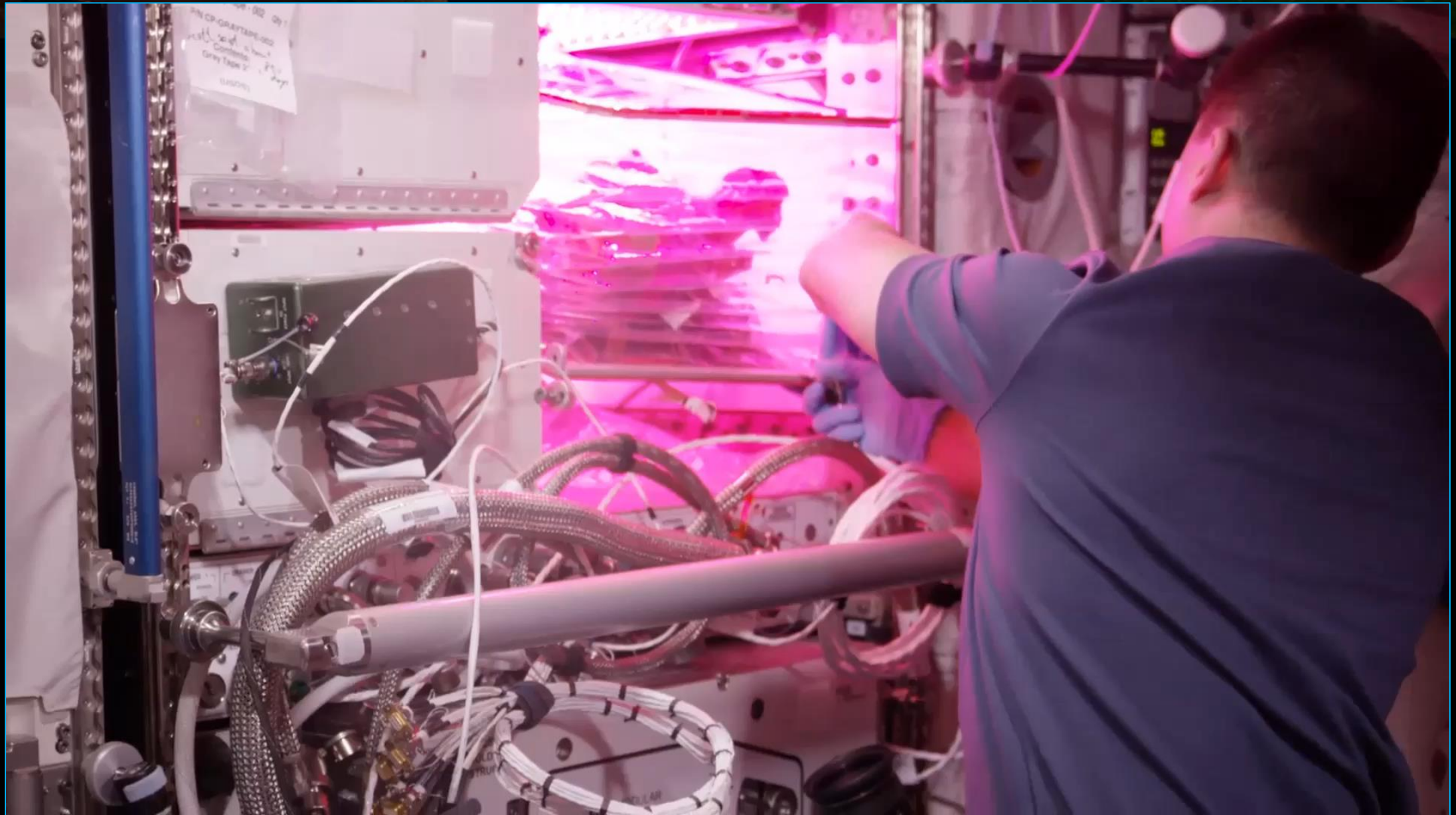
The International Space Station



Current NASA Large Plant Research Capabilities On ISS



VEG-01B Harvest (August 2015)



Astronaut Comments

- Scott Kelly

- the logistical complexity of having people live and work in space for long periods
- the supply chain that is required
- For Mars, need a space craft that is more self-sustainable with regards to its food supply

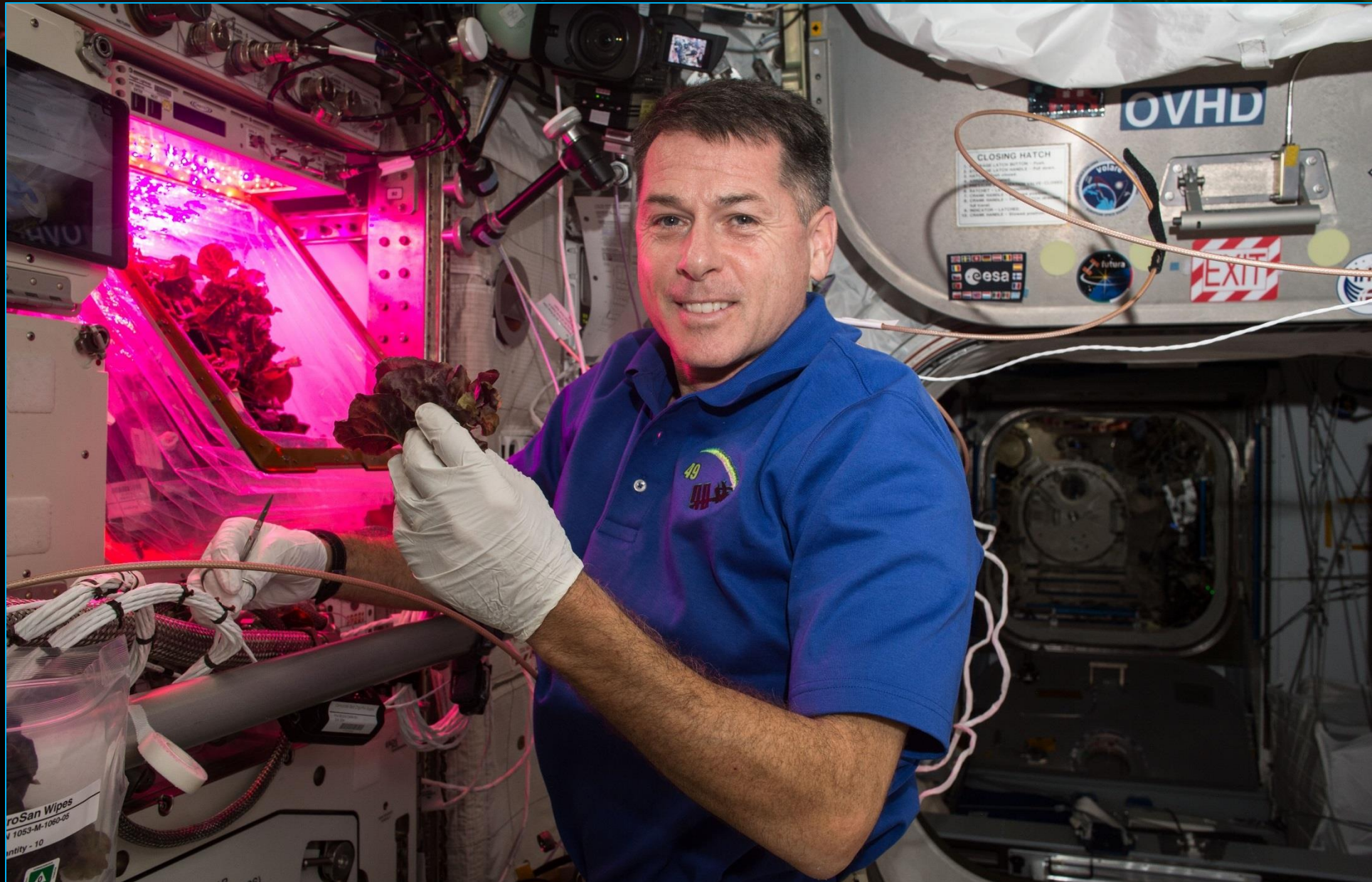


- Kjell Lindgren

- benefit of eating the fresh food
- contribution that plants have to the ISS ecosystem
- psychological benefit - it's really fun to see green growing things in the sterile environment of the ISS



Red Lettuce Cut-and-Come-Again



VEG-03 New Crops on Orbit

- Red Russian Kale
- *Dragoon Lettuce
- Wasabi Mustard
- *Extra Dwarf Pak Choy
- Amara Mustard

Grown in different combinations
with Amara Mustard and Extra
Dwarf Pak Choi harvested recently
on ISS!

*= Student Selected Crops!



VEG-04

Research to study the impacts of Red: Blue: Green light ratios on Mizuna crop growth, nutrient composition, organoleptic appeal and microbial food safety with additional assessments of crew behavioral health.

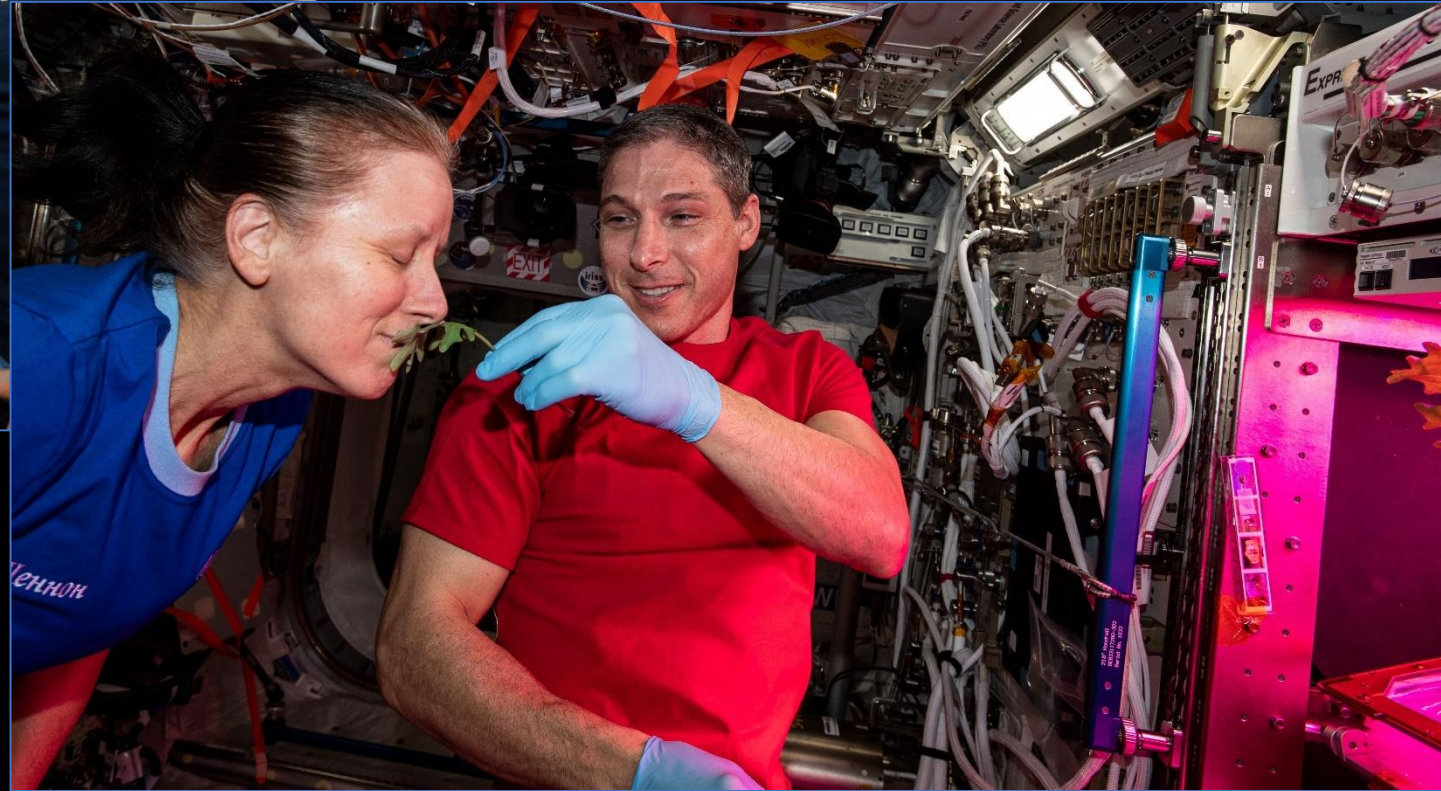
Collaboration between KSC, JSC, Purdue University and SNC-ORBITEC



VEG-04 Crew Engagement



Plant Aromas Also Enhance Astronaut Experiences



Thank you!

